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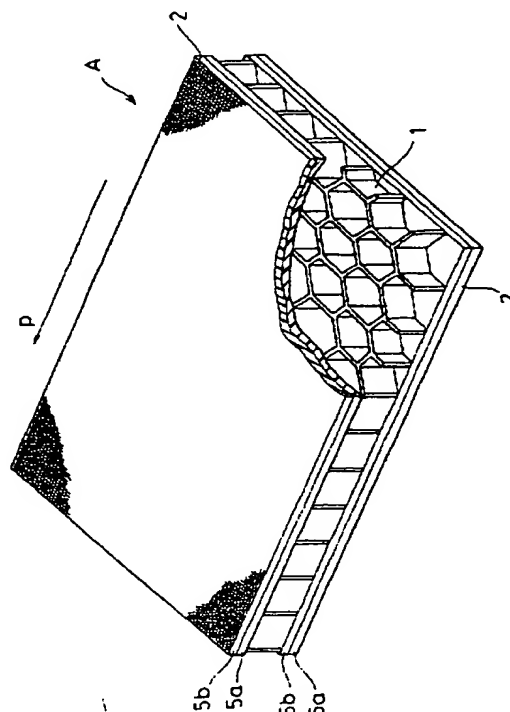
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(54) 【発明の名称】 サンドイッチ構造材

(57) 【要約】

【目的】 軽量であり、耐貫通性とバースルー性が優れているサンドイッチ構造材を提供する。

【構成】 このサンドイッチ構造材は、芯材1の両面に、強化繊維材とマトリクス樹脂とからなる繊維強化樹脂板2を接着してなるサンドイッチ構造材において、強化繊維材は、引張弾性率が $20 \times 10^3 \text{ kgf/cm}^2$ 以上で、かつ、破壊ひずみエネルギーが $4.0 \text{ mm} \cdot \text{kgf/mm}^3$ 以上である炭素繊維系からなる。



## 【特許請求の範囲】

【請求項1】 芯材の両面に、強化繊維材とマトリクス樹脂とからなる繊維強化樹脂板を接着してなるサンドイッチ構造材において、前記強化繊維材は、引張弾性率が  $20 \times 10^3 \text{ kgf/cm}^2$  以上で、かつ、破壊ひずみエネルギーが  $4.0 \text{ mm} \cdot \text{kgf/mm}^3$  以上である炭素繊維系からなることを特徴とするサンドイッチ構造材。

【請求項2】 前記強化繊維材は炭素繊維織物を含み、かつ、その炭素繊維織物は、目抜き部の個数が  $1 \text{ m}^2$  当たり  $400 \sim 60,000$  個であり、カバーファクターが  $95\%$  以上である、請求項1のサンドイッチ構造材。

【請求項3】 前記芯材が、不燃性もしくは難燃性の、プラスチック発泡体またはハニカム構造体である、請求項1のサンドイッチ構造材。

【請求項4】 前記マトリクス樹脂がフェノール樹脂である、請求項1のサンドイッチ構造材。

## 【発明の詳細な説明】

## 【0001】

【産業上の利用分野】 本発明はサンドイッチ構造材に関し、さらに詳しくは、航空機の床材や内装材のような構造材として好適なサンドイッチ構造材に関する。

## 【0002】

【従来の技術】 人工衛星や航空機のような飛行体の分野では、それらの構造材料を軽量化することに基づく省エネルギー効果が顕著である。とくに民間航空機の場合は、就航回数が多く、飛行距離も長いので、その構造材料を軽量化することによって、燃費節約を図ることが追求されている。

【0003】 航空機の構造材料のうち、床材や内装材などは航空機の全面に使用されており、その使用面積はかなり広く、また使用重量もかなり重くなる。上記した床材や内装材のような構造材料としては、従来から、たとえば、ハニカム構造体を芯材とし、その両面にガラス繊維強化樹脂板を表皮材として接着したサンドイッチ構造材が主として使用されてきた。

【0004】 このサンドイッチ構造材の場合、とくに床材として使用したときは、曲げ強さ、曲げ剛性、耐貫通性、バーンスルー性などの特性に優れていることが要求される。とりわけ、航空機の安全確保という点からいうと、耐貫通性とバーンスルー性に優れていることが必要とされている。たとえば、耐貫通性に劣るサンドイッチ構造材を床材に用いた場合には、つぎのような事故を招くこともある。

【0005】 すなわち、高空を飛行中の民間航空機では、客室は予圧室として加圧状態にあり、客室の下部に位置する貨物室は加圧状態になっていないので、仮に耐貫通性があまり優れていない床材である場合には、たとえば女性のハイヒールの踵のような鋭利な部材によって表皮材に穴などがあくと、客室側の圧力で貨物室側の表皮材が芯材から剥離して、床材の破壊が進んでしまう。

そして、床材の破壊が進むと、客室側の空気が貨物室側に急激な勢いで流れ込み、床を支えている桁材も破壊されて航空機全体の機能が停止するようなことも起こるからである。

【0006】 また、バーンスルー性とは、航空機の内部または外部で発生した火災に対し、床材や内装材が、一定の時間、炎を遮断してその拡大を抑制する性質を示す特性であり、通常、カバーファクターの大小で判定されている。ここで、カバーファクターとは、表皮材である繊維強化樹脂板において面積  $S_1$  の領域を設定したときに、その面積  $S_1$  と当該領域内に存在する強化繊維材以外の部分が占める面積  $S_2$  とから、次式：

$$Cf(\%) = [(S_1 - S_2) / S_1] \times 100$$

に基づいて算出される値のことをいう。

【0007】 たとえば、強化繊維材がたて糸とよこ糸を製織した織物である場合、たて糸とよこ糸の交錯部に形成される空隙部、すなわち目抜き部の面積を領域  $S_1$  内で総和した値が、上記した面積  $S_2$  になる。この  $Cf$  値が大きくなると、強化繊維材における上記空隙部は少なくなるので、その表皮材は、炎の吹き抜けに対する抵抗が大きくなりバーンスルー性は向上する。そして  $Cf$  値が小さい表皮材の場合は、上記空隙部が多くなっていて、そこからの炎の吹き抜けは容易になるので、バーンスルー性は低くなる。

【0008】 ガラス繊維強化樹脂板を表皮材とする従来のサンドイッチ構造材の場合、ガラス繊維の融点は低く、たとえば表皮材が接炎するとガラス繊維は短時間で溶融してしまうのでバーンスルー性は劣悪である。また、ガラス繊維の比重は、約  $2.56$  と大きく、しかも弾性率が小さいので、サンドイッチ構造材の実使用時における所定の剛性を満たすためには、表皮材の厚みを厚くすることが必要になる。しかし、表皮材の厚みを厚くする場合は、ガラス繊維の使用量も増量することが必要になるので、結果として、表皮材全体は重いものになってしまう。

【0009】 ところで、最近では、床材や内装材などとして用いるサンドイッチ構造材の軽量化を図るために、表皮材である繊維強化樹脂板の強化繊維材として、炭素繊維織物を使用することが行われている。その場合、表皮材のバーンスルー性を向上させるため、すなわち、炭素繊維織物の  $Cf$  値を大きくするとともに繊維強化樹脂板の強度を高めるために、炭素繊維織物としては、通常、細い炭素繊維系を高密度に製織したものが使用されている。

【0010】 この表皮材の場合、炭素繊維は、その比重が  $1.75$  程度であって、前記したガラス繊維に比べて軽量である。そして、曲げ強さや曲げ剛性などの機械的特性は、表皮材として要求される特性を十分に満たすことができるので、この機械的特性との関係のみを考えれば、表皮材の厚みを薄くしても不都合ではない。しかし

ながら、耐貫通性の確保という点からすると、表皮材の厚みをあまり薄くすることはできない。したがって、結果的には、表皮材の厚みを厚くせざるを得ないため、顕著な軽量化は達成されていない。

【0011】また、この表皮材に火炎を当てると、炭素繊維は存在せずマトリクス樹脂のみが存在する箇所、すなわち目抜き部から、まず、わずかではあるが、炎が吹き抜ける。そして、時間の経過とともに、目抜き部近傍に位置する炭素繊維の酸化消耗が進んで、当初は小さかった吹き抜け穴が大きくなり、そこから炎は高く立ち上がる。

【0012】しかも、強化繊維材が、上記した細い炭素繊維系の高密度繊維である場合、その繊維は単位面積当りの目抜き部の個数が多い、すなわち、隣接する目抜き部間の間隔が狭いので、各目抜き部から吹き抜けた炎が短時間のうちに集合して大きな炎になり、高く立ち上がるという事態が発生しやすい。また、複数枚の繊維を互いの繊維配向が同一方向となるように重ねてなる表皮材や、複数枚の繊維を互いの繊維配向が $0^\circ/90^\circ$ と $+45^\circ/-45^\circ$ となるように重ねてなる、機械的特性が疑似等方性の表皮材の場合であっても、元来、各繊維における目抜き部の個数は多いので、各繊維を重ねたときに、目抜き部が重なりあう頻度と重なりあう面積も大きくなり、前記した場合と同様に、目抜き部から吹き抜けた小さな炎は短時間で集合して大きな炎になりやすい。

【0013】さらに、マトリクス樹脂と複合する炭素繊維繊維物が、細い炭素繊維系を高密度に製織したものであると、繊維の表面が繊維系の屈曲によって凹凸面になっているため、得られた表皮材もまた、その表面が凹凸面になるという問題があり、また、繊維系そのものも高価であるため、サンドイッチ構造材それ自体も高価になるという問題がある。

【0014】

【発明が解決しようとする課題】本発明は、従来のサンドイッチ構造材における上記した問題を解決し、全体として軽量で、耐貫通性とパンスルー性に優れ、表面が平滑で、かつ、安価に製造することができるサンドイッチ構造材の提供を目的とする。

【0015】

【課題を解決するための手段】上記した目的を達成するために、本発明においては、芯材の両面に、強化繊維材とマトリクス樹脂とからなる繊維強化樹脂板を接着した構造のサンドイッチ構造材において、前記強化繊維材は、引張弾性率が $20 \times 10^3 \text{ kgf/cm}^2$ 以上で、かつ、破壊ひずみエネルギーが $4.0 \text{ mm} \cdot \text{kgf/mm}^3$ 以上である炭素繊維系からなることを特徴とするサンドイッチ構造材が提供される。

【0016】

【実施態様】以下に、本発明のサンドイッチ構造材の例

を図面に則して詳細に説明する。図1は、サンドイッチ構造材Aを示す一部切欠斜視図である。図において、ハニカム構造体である芯材1の両面には、表皮材が接着されており、各表皮材は複数枚（図1では2枚）の強化繊維材5a、5bを積層した繊維強化樹脂板になっている。

【0017】芯材1は、サンドイッチ構造材全体の軽量化を図るとともに機械的強度を確保することからすると、その密度は $0.017 \sim 0.17 \text{ g/cm}^3$ であることが好ましい。密度が $0.017 \text{ g/cm}^3$ より小さいものは、その機械的強度が低くなって、得られたサンドイッチ構造体は座屈を起こしやすくなり、構造材の芯材としての機能を十分に発揮することができず、また、 $0.17 \text{ g/cm}^3$ より大きいものを用いると、全体の重量が重くなって軽量化の意図に反するようになるからである。

【0018】芯材1としては、図示したハニカム構造体の外に、プラスチック発泡体を使用してもよい。サンドイッチ構造材を航空機の内装材として用いる場合には、芯材1がアルミニウムのハニカム構造体であると、芯材1は不燃性であるので好適である。また、アラミド繊維紙のハニカムにたとえばフェノール樹脂を含浸したハニカム構造体や、たとえばフェノール樹脂を発泡させたフェノールフォームなどは、いずれも自己消炎性、難燃性であるため、芯材1として好適である。

【0019】つぎに、表皮材2について説明する。表皮材2は、強化繊維材が炭素繊維系からなり、その強化繊維材とマトリクス樹脂とを複合した繊維強化樹脂板である。この繊維強化樹脂板を構成するマトリクス樹脂としては、たとえば、エポキシ樹脂、フェノール樹脂、不飽和ポリエステル樹脂、ビニルエステル樹脂のような熱硬化性樹脂や、ポリアミド樹脂、ポリエステル樹脂、ポリエチレン樹脂、ポリプロピレン樹脂、ポリフェニレンサルフィド樹脂、ポリイミド樹脂、ポリエーテルエーテル樹脂、ABS樹脂、アセタール樹脂のような熱可塑性樹脂などをあげることができる。

【0020】これらマトリクス樹脂には、たとえば、リン酸エステル、ハロゲン化炭化水素、酸化アンチモンやホウ酸亜鉛、含リンポリオール、含臭素ポリオール、四塩化無水フタル酸、四臭化無水フタル酸のような公知の難燃剤を配合して難燃性を付与してもよい。その場合、マトリクス樹脂の燃焼時に、これら難燃剤から人体に有害なガス成分を発生することもあるので、難燃剤の配合量は適量に制限すべきである。

【0021】上記したマトリクス樹脂のうち、フェノール樹脂は、難燃剤を配合しなくても優れた難燃性を備えており、燃焼時における発生ガス量が少なく、また、炭化率が高いので燃焼後にあつては炭化物として残り、それが炎を遮断する働きを発揮するので好適である。この繊維強化樹脂板において、マトリクス樹脂の複合割合は35～65重量%になっていることが好ましい。この割

合が35重量%より少ない場合は強化繊維材の割合が65重量%より多くなり、また、65重量%より多い場合は強化繊維材の割合が35重量%より少なくなり、いずれの場合であっても、繊維と樹脂との複合化に伴う強度向上が不十分になるからである。

【0022】つぎに、強化繊維材として用いる炭素繊維糸としては、PAN系の炭素繊維糸や、ピッチ系の炭素繊維糸などのいずれであってもよいが、下記の特性を有する高靱性炭素繊維糸が使用される。すなわち、JIS R7601に準拠して測定される引張弾性率（E：kgf/mm<sup>2</sup>）が $2.0 \times 10^3$  kgf/mm<sup>2</sup>以上であり、かつ、破壊ひずみエネルギー（W：mm・kgf/mm<sup>3</sup>）が4.0 mm・kgf/mm<sup>3</sup>以上の炭素繊維糸である。

【0023】なお、ここで、破壊ひずみエネルギーとは、JIS R7601に準拠して測定したときの引張強度（ $\sigma$ ：kgf/mm<sup>2</sup>）と、上記したE値とを用いて、次式： $W = \sigma^2 / 2E$ に基づいて算出される値のことをいう。Eが $2.0 \times 10^3$  kgf/mm<sup>2</sup>より小さい炭素繊維糸を用いて表皮材を製造した場合、表皮材に適正な耐貫通性と機械的強度付与するためには、炭素繊維糸を比較的多量に複合することが必要となり、その結果、表皮材の重量は重くなり、軽量化の目的に反するようになる。

【0024】また、破壊ひずみエネルギーが4.0 mm・kgf/mm<sup>3</sup>より低い炭素繊維糸を用いて製造された表皮材においては、その表皮材に外部から衝撃が加わったとき、衝撃箇所近辺の芯材の圧壊が起こるとともに、表皮材に複合されている炭素繊維糸それ自体も切断されやすく、そのため、低い衝撃エネルギーが加わった場合であっても、表皮材に穴があきやすくなる。

【0025】なお、上記した炭素繊維糸としては、単糸径が4～10  $\mu$ mのマルチフィラメントが使用される。本発明の強化繊維材の1例を、図2に斜視図として示す。この強化繊維材Bは、よこ糸3a、たて糸3bとして炭素繊維扁平糸を用いて、これらを製織した織物である。

【0026】この織物では、よこ糸3aとたて糸3bの交錯部に目抜き部4が形成される。本発明においては、この目抜き部4の個数が、織物1m<sup>2</sup>当り400～6000個であり、かつ、前記したCf値が95%以上である織物を用いることが好ましい。単位面積（1m<sup>2</sup>）当りの目抜き部4の個数が少ない織物は、隣接する目抜き部相互間の間隔が大きいので、表皮材が接炎したときに、個々の目抜き部から吹き抜けた炎が集合して大きな炎に成長するまでに要する時間は長くなり、バーンスルー性は向上する。

【0027】しかしながら、目抜き部4の個数が少なすぎると、その織物は剪断変形に対する自由度が小さくなり、表皮材の製造時において、この織物に樹脂含浸してなるプリプレグをたとえば曲面に沿って成形する際に、成形体の表面に皺などが発生するようになる。このよう

なことから、織物における目抜き部4の個数は400個/m<sup>2</sup>以上にするのが好ましい。

【0028】また、目抜き部4の個数が多すぎる場合は、隣接する目抜き部相互間の間隔は狭くなるため、目抜き部を吹き抜けた炎は短時間で集合して大きな炎に成長しやすく、表皮材のバーンスルー性は低下する。したがって、目抜き部4の個数は60,000個/m<sup>2</sup>以下にすることが好ましい。さらに、用いる織物においては、Cf値が小さい織物では、1個当りの目抜き部面積が大きいので、その目抜き部を埋めている樹脂が燃焼して目抜き部から吹き抜け、大きな炎に成長する時間は短くなる。そのため、本発明で用いる織物におけるCf値は、95%以上になっていることが好ましい。

【0029】図2で示した炭素繊維扁平糸を製織した織物としては、具体的には、撚りがなく、織度3,000～20,000デニール、糸幅4～16mm、糸幅/糸厚みの比30以上の扁平糸を、糸幅の1.0～1.3倍のピッチで製織してなり、目付けが100～300g/m<sup>2</sup>、厚みが0.1～0.4mmの織物をあげることができる。この織物の場合、製織に用いる炭素繊維糸は、撚りがなく、糸幅が太く、糸幅/糸厚みの比が30以上であるため、目抜き部4の単位面積（1m<sup>2</sup>）当りの個数を400～60,000個/m<sup>2</sup>にすることができ、バーンスルー性、耐貫通性、成形性のいずれもが良好である。

【0030】また、糸幅の1.0～1.3倍のピッチで製織されているので、そのCf値は95～99.5%の範囲内にあり、バーンスルー性に富む。さらには、この織物は厚みが0.1～0.4mmの扁平糸で製織されているので、織物表面には繊維の屈曲に基づく凹凸はあまり発生しない。また、目付けも100～300g/m<sup>2</sup>と小さい。したがって、この織物を用いて製造した表皮材は、表面が平滑でしかも軽量である。さらに、用いる炭素繊維糸は太いので安価に製造することができ、最終のサンドイッチ構造材も安価になる。

【0031】図2で示した織物は、たとえば、つぎのようにして製織することができる。すなわち、扁平糸からなるよこ糸が巻回されているよこ糸ボビンからよこ糸を横取り解舒し、ガイドローラによってそのよこ糸をよこ糸供給装置位置で水平方向に位置決めするとともに、前記よこ糸ボビンとガイドローラとの間で、たて糸に対する1回のよこ糸供給に必要な長さのよこ糸を保留しつつ、緊張下においてよこ糸を供給する。一方、扁平糸からなるたて糸が巻回されている複数巻のたて糸ボビンのそれぞれからたて糸を横取り解舒し、これら複数本のたて糸を、コームを用いて、たて糸の扁平面がコームのワイヤ以外には接触しないようにしながら所望密度に引き揃え、それぞれのたて糸の扁平面を水平方向に変換して綜統に導くことによって製織される。

【0032】このようにして製織された織物の場合は、たて糸およびよこ糸に撚りははらず、たて糸およびよ

こ糸の扁平状態は保持され、糸幅や糸厚みなどの糸形状もほとんど変化しない。図1で示したサンドイッチ構造材は、たとえば、つぎのようにして製造することができる。

【0033】まず、図2で示したような炭素繊維扁平糸の織物を、マトリクス樹脂をたとえばメタノールのような溶媒で希釈してなる樹脂液に浸漬して織物に樹脂含浸を行う。ついで、織物を取り出し、溶媒を乾燥除去して、所定量の樹脂が付着している織物プリプレグを調製する。得られた織物プリプレグの所望枚数を積層し、その上に所望形状に加工した芯材を置き、さらに、その芯材の上に所望枚数の上記織物プリプレグを載せたのち、全体をオートクレーブ中にセットし、所定の温度、所定の圧力で熱圧処理することにより、マトリクス樹脂を硬化して表皮材を形成するとともに、その表皮材と芯材とを接着する。

【0034】上記した実施態様においては、表皮材である繊維強化樹脂板における強化繊維材が炭素繊維扁平糸の織物であるが、本発明の強化繊維材はこれに限定されるものではなく、たとえば、前記した引張弾性率と破壊ひずみエネルギーを有する炭素繊維糸を一方向に並行に引き揃えた一方向材や織物であってもよい。表皮材が、複数枚の強化繊維材を積層した繊維強化樹脂板である場合には、表皮材における強化繊維がいずれも同一方向に揃うように配列されていてもよく、また、各表皮材における強化繊維を、相互に、 $0^\circ/90^\circ$ と $+45^\circ/-45^\circ$ に配列して、表皮材全体が疑似等方性を示すように積層してもよい。

【0035】その場合、図1における表皮材2における強化繊維材5b、5bの強化繊維は、図の矢印p方向に対し $0^\circ/90^\circ$ 方向に配向させ、また強化繊維材5a、5aは、矢印p方向に対し $+45^\circ/-45^\circ$ 方向

に配向させたものを、芯材1に対して鏡面对称に配置することが好ましい。また、図2で示した炭素繊維扁平糸織物と通常の炭素繊維織物とを積層して表皮材にしてもよい。その場合、前者の表皮材を最外層に配置すると表皮材全体の表面は平滑面になり、必要に応じては、そこに塗装を施したり、他のフィルムを貼着したりして意匠性を高めることができる。

【0036】

【発明の効果】以上の説明で明らかなように、本発明のサンドイッチ構造材は、軽量であり、耐貫通性とバンスルー性のいずれもが優れていて、航空機の床材や内装材として有用である。これは、表皮材を構成する強化繊維材として、引張弾性率が $20 \times 10^3 \text{ kgf/cm}^2$ 以上で、かつ、破壊ひずみエネルギーが $4.0 \text{ mm} \cdot \text{kgf/mm}^3$ 以上である炭素繊維糸を用いたことがもたらす効果である。とくに、強化繊維材として織物を用いたときに、その織物における目抜き部の個数を $400 \sim 60,000$ 個/ $\text{m}^2$ とし、かつ、カバーファクター(Cf)を95%以上にしたことがもたらす効果である。

【図面の簡単な説明】

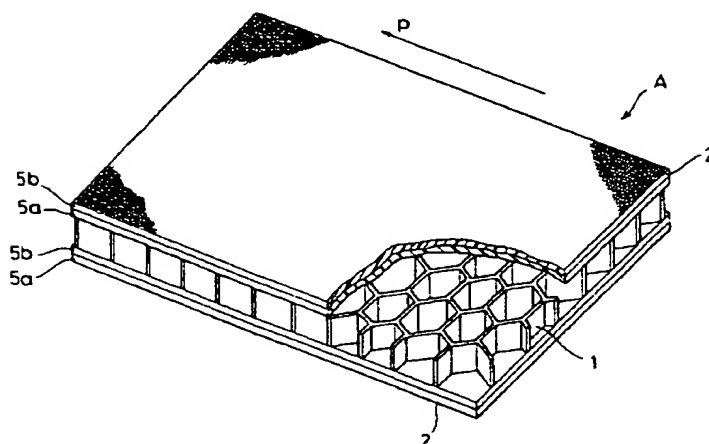
【図1】本発明の実施態様を示す一部切欠斜視図である。

【図2】本発明のサンドイッチ構造材の表皮材における強化繊維材の1例を示す炭素繊維扁平糸織物の斜視図である。

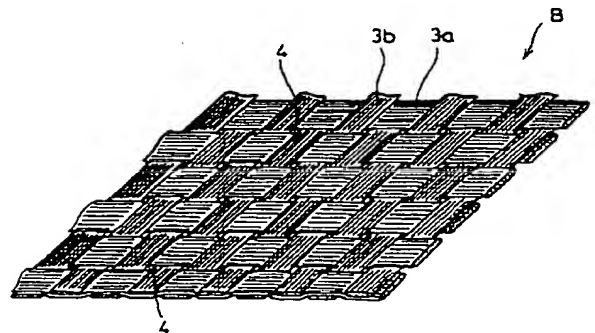
【符号の説明】

- 1 ハニカム構造体(芯材)
- 2 表皮材
- 3a 炭素繊維扁平糸からなるよこ糸
- 3b 炭素繊維扁平糸からなるたて糸
- 4 目抜き部
- 5a, 5b 強化繊維材

【図1】



【図2】



フロントページの続き

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(Translation)

Mailed: March 25, 2003

**NOTIFICATION OF REASONS FOR REJECTION**

Patent Application No.: 2000-192889

Examiner's Notice Date: March 19, 2003

Examiner: Yasuyuki Kawabata

This application is rejected on the grounds stated below. Any opinion about the rejection must be filed within 60 DAYS of the mailing date hereof.

**REASONS**

1. The invention is unpatentable under Section 29 (1) (iii) of the Patent Law as being described in the following publication distributed prior to this application or made available to the public through electric telecommunication lines in Japan or a foreign country prior to this application.

2. The invention is unpatentable under Section 29 (2) of the Patent Law, as being such that the invention could easily have been made by a person with ordinary skill in the art to which the invention pertains, on the basis of the invention described in the following publication(s) distributed in Japan or a foreign country prior to this application or the invention made available to the public through electric telecommunication lines in Japan or a foreign country prior to this application.

**REMARKS**

Claims 1-3

References Cited: 1 Jpn. Pat. Appln. KOKAI Publication No. 7-125118  
2 Jpn. Pat. Appln. KOKAI Publication No. 5-208465

Note: Refer to reference 1, claim 1 and 4.

Also, a sandwich panel with plastic reinforced with carbon fibers used for the surface material (refer to claim 1) is described in reference 2, and phenolic resin is used as the pre-preg matrix resin (refer to the embodiments).

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発送番号 0 9 8 9 1 3

発送日 平成 1 5 年 3 月 2 5 日 1 / 2

## 拒絶理由通知書

特許出願の番号	特願 2 0 0 0 - 1 9 2 8 8 9
起案日	平成 1 5 年 3 月 1 9 日
特許庁審査官	川端 康之 9 1 5 6 4 S 0 0
特許出願人代理人	鈴江 武彦 (外 4 名) 様
適用条文	第 2 9 条第 1 項、第 2 9 条第 2 項

この出願は、次の理由によって拒絶をすべきものである。これについて意見があれば、この通知書の発送の日から 6 0 日以内に意見書を提出して下さい。

## 理 由

1) この出願の下記の請求項に係る発明は、その出願前に日本国内又は外国において、頒布された下記 of 刊行物に記載された発明又は電気通信回線を通じて公衆に利用可能となった発明であるから、特許法第 2 9 条第 1 項第 3 号に該当し、特許を受けることができない。

2) この出願の下記の請求項に係る発明は、その出願前日本国内又は外国において頒布された下記 of 刊行物に記載された発明又は電気通信回線を通じて公衆に利用可能となった発明に基いて、その出願前にその発明の属する技術の分野における通常の知識を有する者が容易に発明をすることができたものであるから、特許法第 2 9 条第 2 項の規定により特許を受けることができない。

## 記

- ・請求項 1 ～ 3
- ・引用例 1 特開平 7 - 1 2 5 1 1 8 号公報
- 2 特開平 5 - 2 0 8 4 6 5 号公報
- ・備考

引用例 1 の請求項 1, 4 参照。

また、引用例 2 には炭素繊維強化プラスチックを表面材に使用したサンドイッチパネルが記載され (請求項 1 参照)、プリプレグのマトリックス樹脂としてはフェノール樹脂が用いられている (実施例参照)。

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先行技術文献調査結果の記録

櫻井 重エ

発送番号 098913

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- ・調査した分野 I P C第7版. B 3 2 B 1 / 0 0 - 3 5 / 0 0
- ・先行技術文献 なし

この先行技術文献調査結果の記録は、拒絶理由を構成するものではない。

(この拒絶理由通知の内容についてお問い合わせがある場合には、下記までご連絡下さい。)

T E L 03-3501-0639

F A X 03-3501-0698

特許審査第3部繊維・積層 川端 康之)

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DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]

[Drawing 1] the embodiment of this invention is shown -- it is a notch perspective diagram in part

[Drawing 2] It is the perspective diagram of the carbon fiber flat thread textiles in which one example of the strengthening fiber material in the epidermis material of the sandwich-structure material of this invention is shown.

[Description of Notations]

1 Honeycomb-Structure Object (Core Material)

2 Epidermis Material

3a Weft yarn which consists of carbon fiber flat thread

3b Warp which consists of carbon fiber flat thread

4 Main Section

5a, 5b Strengthening fiber material

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[Translation done.]

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CLAIMS

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[Claim(s)]

[Claim 1] It sets to the sandwich-structure material which comes to paste up the fiber strengthening resin board which becomes both sides of a core material from a strengthening fiber material and a matrix resin, and, for the aforementioned strengthening fiber material, a modulus of elasticity in tension is  $20 \times 10^3$  kgf/cm<sup>2</sup>. It is above and destructive strain energy is 4.0 mm-kgf/mm<sup>3</sup>. Sandwich-structure material characterized by the bird clapper from the carbon fiber thread which it is above.

[Claim 2] The aforementioned strengthening fiber material contains carbon fiber textiles, and, for the carbon fiber textiles, the number of the main section is 2 lm. Sandwich-structure material of a claim 1 whose covering factor it is 400-60,000 hits and is 95% or more.

[Claim 3] Sandwich-structure material of a claim 1 whose aforementioned core material is noncombustible or fire-resistant a plastics foam or a honeycomb-structure object.

[Claim 4] Sandwich-structure material of a claim 1 whose aforementioned matrix resin is phenol resin.

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[Translation done.]

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## DETAILED DESCRIPTION

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[Detailed Description of the Invention]

[0001]

[Industrial Application] this invention relates to sandwich-structure material suitable as structure material like the flooring of the aircraft, or interior material in more detail about sandwich-structure material.

[0002]

[Description of the Prior Art] In the field of an airframe like a satellite or the aircraft, the energy-saving effect based on lightweight-izing those structural materials is remarkable. Since there is much number of times of a service especially in the case of a civil aviation machine and flight distance is also long, aiming at mpg saving is pursued by lightweight-izing the structural material.

[0003] Among the structural materials of the aircraft, flooring, interior material, etc. are used all over the aircraft, and, as for the operating area, become quite heavy [ an operating weight ] quite widely. As a structural material like the above-mentioned flooring or interior material, from the former, the honeycomb-structure object was made into the core material, and the sandwich-structure material which pasted up the glass fiber strengthening resin board on the both sides as epidermis material has mainly been used, for example.

[0004] When it is used especially as flooring in the case of this sandwich-structure material, to excel in properties, such as bending strength, flexural rigidity, penetration-proof, and barn through nature, is demanded. Especially, if it says from the point of the security of the aircraft, to excel in penetration-proof and barn through nature is needed. For example, the following accident may be caused when the sandwich-structure material inferior to penetration-proof is used for flooring.

[0005] That is, if a hole etc. opens in epidermis material by sharp member like [ when it is flooring in which penetration-proof is seldom temporarily excellent since the cargo compartment which a cabin has in a pressurization state as a pre-load room in the civil aviation machine under flight by altitude, and is located in the lower part of a cabin is not in the pressurization state ] the heel of female high-heeled shoe, the epidermis material by the side of a cargo compartment will exfoliate from a core material by the pressure by the side of a cabin, and destruction of flooring will progress. And it is because it will happen that the air by the side of a cabin flows into a cargo-compartment side with rapid vigor, the digit material supporting the floor is also destroyed, and the function of the whole aircraft stops if destruction of flooring progresses.

[0006] Moreover, barn through nature is a property which shows the property in which flooring and interior material intercept fixed time and flame, and suppress the expansion to the fire which broke out in the interior or the exterior of the aircraft, and it is usually judged by the size of a covering factor. the fiber strengthening resin board whose covering factor is epidermis material here -- setting -- area S1 the time of setting up a field -- the area S1 Area S2 which portions other than the strengthening fiber material which exists in the field concerned occupy from -- following -- the thing of the value computed based on formula:  $Cf(\%) = [(S1 - S2) / S1] \times 100$  is said

[0007] For example, it is a field S1 about the area of the opening section formed in the mixture section of warp and weft yarn when strengthening fiber materials are the textiles which carried out weaving of warp and the weft yarn, i.e., the main section. Area S2 which the value totaled inside described above It becomes. If this Cf value becomes large, since the above-mentioned opening section in a strengthening fiber material will decrease, resistance of as opposed to the blow by of flame in the epidermis material becomes large, and barn through nature's improves. And since the above-mentioned opening section has increased and the blow by of the flame from there becomes easy when Cf value is small epidermis material, barn through nature becomes low.

[0008] In the case of the conventional sandwich-structure material which makes a glass fiber strengthening resin board epidermis material, the melting point of a glass fiber is low, for example, since a glass fiber will be fused for a short time if epidermis material \*\*\*\*, barn through nature is inferior. The specific gravity of a glass fiber is as large as about 2.56, and moreover, since the elastic modulus is small, in order to fulfill the predetermined rigidity at the time of real use of sandwich-structure material, it is necessary to thicken thickness of epidermis material. However, since it is necessary for the amount of the glass fiber used to also increase when thickening thickness of epidermis material, the whole epidermis material will become heavy as a result.

[0009] By the way, in order to attain lightweight-ization of the sandwich-structure material used as flooring, interior material, etc. recently, using carbon fiber textiles is performed as a strengthening fiber material of the fiber strengthening resin board which is epidermis material. In this case, in order to raise the barn through nature of epidermis material (i.e., while enlarging Cf value of carbon fiber textiles, in order to raise the intensity of a fiber strengthening resin board), as carbon fiber textiles,

what carried out weaving of the narrow carbon fiber thread with high density is usually used.

[0010] In the case of this epidermis material, the specific gravity is about 1.75 and a carbon fiber's is lightweight compared with said glass fiber. And since the property demanded as epidermis material can fully be fulfilled, even if mechanical properties, such as bending strength and flexural rigidity, make thickness of epidermis material thin, considering only a relation with this mechanical property, they are not inconvenient. However, thickness of epidermis material cannot be made not much thin, considering the point of reservation of penetration-proof. Therefore, as a result, since thickness of epidermis material must be thickened, remarkable lightweight-ization is not attained.

[0011] Moreover, first, if a flame is applied to this epidermis material, although it is small, flame will blow from the part where a carbon fiber does not exist but only a matrix resin exists, i.e., the main section. And with the passage of time, the oxidative consumption of a carbon fiber located near the main section progresses, the small blow-by hole becomes large at the beginning, and flame starts from there highly.

[0012] And when strengthening fiber materials are the high-density textiles of the above-mentioned narrow carbon fiber thread, the textiles have much number of the main section per unit area, namely, since the interval between the adjoining main sections is narrow, it is easy for the flame blown from each main section to gather to the inside of a short time, to turn into big flame, and to generate the situation of starting highly. Moreover, the epidermis material which becomes in piles so that mutual fiber orientation may turn into the same direction in the textiles of two or more sheets, Even if it is the case where the mechanical property which becomes in piles is the epidermis material of false isotropy so that mutual fiber orientation may become 0 degree / 90 degrees, +45 degrees / -45 degrees, since there is much number of the main section in each textiles, originally the textiles of two or more sheets When each textiles are piled up, like the case where the area which overlaps the frequency which the main section overlaps also became large, and is described above, the small flame blown from the main section gathers for a short time, and tends to turn into big flame.

[0013] Furthermore, since the front face of textiles has become that the carbon fiber textiles compounded with a matrix resin carry out weaving of the narrow carbon fiber thread with high density by crookedness of weaving yarn in the concavo-convex field, there is a problem that the front face turns into a concavo-convex field, and since weaving yarn itself is expensive, the obtained epidermis material also has the problem of becoming expensive also in itself [ sandwich-structure material ].

[0014]

[Problem(s) to be Solved by the Invention] this invention solves the above-mentioned problem in the conventional sandwich-structure material, is lightweight as a whole, is excellent in penetration-proof and barn through nature, and aims at offer of the sandwich-structure material which a front face can manufacture cheaply flat and smooth.

[0015]

[Means for Solving the Problem] It sets to the sandwich-structure material of structure which pasted up the fiber strengthening resin board which becomes both sides of a core material from a strengthening fiber material and a matrix resin in this invention in order to attain the above-mentioned purpose, and, for the aforementioned strengthening fiber material, a modulus of elasticity in tension is  $20 \times 10^3$  kgf/cm<sup>2</sup>. It is above and destructive strain energy is 4.0 mm-kgf/mm<sup>3</sup>. The sandwich-structure material characterized by the bird clapper from the carbon fiber thread which it is above is offered.

[0016]

[Example] Below, the example of the sandwich-structure material of this invention is **\*\* (ed)** on a drawing, and it explains in detail. drawing 1 shows the sandwich-structure material A -- it is a notch perspective diagram in part In drawing, epidermis material has pasted both sides of the core material 1 which is a honeycomb-structure object, and each epidermis material has become the fiber strengthening resin board which carried out the laminating of the strengthening fiber materials 5a and 5b of two or more sheets ( drawing 1 two sheets).

[0017] considering [ of securing a mechanical strength while a core material 1 attains lightweight-ization of the whole sandwich-structure material ] -- the density -- 0.017 - 0.17 g/cm<sup>3</sup> it is -- things are desirable Density is 0.017 g/cm<sup>3</sup>. The sandwich-structure object with which the mechanical strength became low and the small thing was obtained becomes easy to cause buckling, and cannot fully demonstrate the function as a core material of structure material, and is 0.17 g/cm<sup>3</sup>. It is because the whole weight will become heavy and will come to be contrary to the intention of lightweight-izing, if a large thing is used.

[0018] As a core material 1, you may use a plastics foam out of the illustrated honeycomb-structure object. When using sandwich-structure material as interior material of the aircraft, since a core material 1 is it incombustibility that a core material 1 is the honeycomb-structure object of aluminum, it is suitable. Moreover, since each of honeycomb-structure objects which sank phenol resin into the honeycomb of aramid fiber paper, phenol forms in which phenol resin was made to foam is self-resolution nature and fire retardancy, they is suitable as a core material 1.

[0019] Below, the epidermis material 2 is explained. The epidermis material 2 is the fiber strengthening resin board which compounded the strengthening fiber material and matrix resin by a strengthening fiber material consisting of carbon fiber thread. As a matrix resin which constitutes this fiber strengthening resin board, an epoxy resin, phenol resin, an unsaturated polyester resin, thermosetting resin like vinyl ester resin, polyamide resin, polyester resin, a polyethylene resin, polypropylene resin and a polyphenylene sulfide resin, polyimide resin, a polyether ether resin, ABS plastics, thermoplastics like an acetal resin, etc. can be raised, for example.

[0020] these matrices resin -- for example, phosphoric ester, a halogenated hydrocarbon, an antimony oxide and boric-acid zinc, a phosphorus-containing polyol, a bromine-containing polyol, and a phthalic anhydride tetrachloride -- a well-known flame retarder like phthalic anhydride may be blended 4 bromination, and fire retardancy may be given In this case, since gas

constituents detrimental to a human body may be generated from these flame retarders at the time of combustion of a matrix resin, you should restrict the loadings of a flame retarder to optimum dose.

[0021] Since the work to which phenol resin equips with the fire retardancy which was excellent even if it did not blend a flame retarder, it remains as carbide if it is after combustion, since there is little generating capacity at the time of combustion and the coking value is high, and it intercepts flame among the above-mentioned matrix resins is demonstrated, it is suitable. As for the compound rate of a matrix resin, in this fiber strengthening resin board, it is desirable that it is 35 - 65% of the weight. It is because the improvement in on the strength accompanying composite-izing with fiber and a resin becomes inadequate even if the rate of a strengthening fiber material increases more than 65 % of the weight, and the rate of a strengthening fiber material becomes less than 35 % of the weight when [ than 65 % of the weight ] more, and it is which case when there are few these rates than 35 % of the weight.

[0022] Next, as carbon fiber thread used as a strengthening fiber material, although you may be any, such as carbon fiber thread of a PAN system, and carbon fiber thread of a pitch system, the high toughness carbon fiber thread which has the following property is used. Namely, JIS The modulus of elasticity in tension (E:kgf/mm<sup>2</sup>) measured based on R7601 is 20x10<sup>3</sup> kgf/mm<sup>2</sup>. It is above and destructive strain energy (W:mm-kgf/mm<sup>3</sup>) is 4.0 mm-kgf/mm<sup>3</sup>. It is the above carbon fiber thread.

[0023] In addition, destructive strain energy is JIS here. The thing of the value computed based on following formula:  $W = \sigma^2 / 2E$  is said using the tensile strength ( $\sigma$ :kgf/mm<sup>2</sup>) when measuring based on R7601, and the above-mentioned E value. E is 20x10<sup>3</sup> kgf/mm<sup>2</sup>. When epidermis material is manufactured using small carbon fiber thread, in order to carry out mechanical-strength grant with penetration-proof proper to epidermis material, it is necessary to compound carbon fiber thread comparatively so much, consequently the weight of epidermis material becomes heavy, and it comes to be contrary to the purpose of lightweight-izing.

[0024] Moreover, destructive strain energy is 4.0 mm-kgf/mm<sup>3</sup>. In the epidermis material manufactured using low carbon fiber thread, when a shock joins the epidermis material from the exterior, while collapse of the core material of the shock part neighborhood takes place, even if it is the case where were easy to be cut also in itself [ carbon fiber thread ] which is compounded with epidermis material, therefore low striking energy is added, a hole becomes easy to get bored with epidermis material.

[0025] In addition, as the above-mentioned carbon fiber thread, the multifilament whose diameter of single yarn is 4-10 micrometers is used. One example of the strengthening fiber material of this invention is shown in drawing 2 as a perspective diagram. This strengthening fiber material B is the textiles which carried out weaving of these, using carbon fiber flat thread as weft-yarn 3a and warp 3b.

[0026] The main section 4 is formed in the mixture section of weft-yarn 3a and warp 3b with these textiles. It sets to this invention and the number of this main section 4 is 2 1m of textiles. It is desirable to use the textiles whose Cf value which are 400-60000 hits and was described above is 95% or more. The time taken for the flame blown from each main section to gather, and for the textiles with little number of the main section 4 of per a unit area (1m<sup>2</sup>) to grow up to be big flame when epidermis material \*\*\*\* since the adjoining interval between the main sections is large becomes long, and barn through nature improves.

[0027] However, if there is too little number of the main section 4, the flexibility to a shear strain becomes small, and in case the textiles fabricate the prepreg which comes to carry out resin sinking in along with a curved surface on these textiles at the time of manufacture of epidermis material, a wrinkle etc. will come to generate them on the surface of a Plastic solid. The number of the main section 4 in textiles since it is such is 400 pieces/m<sup>2</sup>. Carrying out above is desirable.

[0028] Moreover, since the adjoining interval between the main sections becomes narrow when there is too much number of the main section 4, the flame which blew the main section gathers for a short time, and tends to grow up to be big flame, and the barn through nature of epidermis material falls. Therefore, the number of the main section 4 is 60,000 pieces/m<sup>2</sup>. It is desirable to make it below. Furthermore, in the textiles to be used, with textiles with small Cf value, since the main aspect product per piece is large, the resin which is burying the main section burns, it blows from the main section, and time to grow up to be big flame becomes short. Therefore, as for Cf value in the textiles used by this invention, it is desirable that it is 95% or more.

[0029] There is no twist, it becomes impossible to specifically carry out weaving of the 30 or more ratios [ of the fineness of 3,000-20,000 deniers, the thread width of 4-16mm, and a thread width / thread thickness ] flat thread in a 1.0 to 1.3 times as many pitch as a thread width as textiles which carried out weaving of the carbon fiber flat thread shown by drawing 2, and a superintendent officer can raise the textiles 100 - 300 g/m<sup>2</sup> and whose thickness are 0.1-0.4mm. since in the case of these - textiles the carbon fiber thread used for weaving does not have a twist, its thread width is thick and the ratio of a thread width / thread thickness is 30 or more -- the number of per a unit area (1m<sup>2</sup>) of the main section 4 -- 400-60,000 pieces/m<sup>2</sup> it can carry out -- both barn through nature penetration-proof and a moldability -- although -- it is good

[0030] Moreover, since weaving is carried out in the 1.0 to 1.3 times as many pitch as a thread width, the Cf value is in 95 - 99.5% of within the limits, and is rich in barn through nature. Furthermore, since weaving of these textiles is carried out with the flat thread whose thickness is 0.1-0.4mm, in a textile front face, the irregularity based on crookedness of weaving yarn is seldom generated. Moreover, a superintendent officer 100 - 300 g/m<sup>2</sup> It is small. Therefore, the epidermis material manufactured using these textiles has a smooth front face, and, moreover, it is lightweight. Furthermore, since the carbon fiber thread to be used is thick, it can be manufactured cheaply, and the last sandwich-structure material also becomes cheap.

[0031] For example, weaving of the textiles shown by drawing 2 can be carried out as follows. That is, while carrying out

usurpation unraveling of the weft yarn from the weft-yarn bobbin around which the weft yarn which consists of flat thread is wound and positioning the weft yarn horizontally by the guide idler in a weft-yarn feeder position, weft yarn is supplied to the bottom of strain between the aforementioned weft-yarn bobbin and a guide idler, suspending the weft yarn of length required for one weft-yarn supply to warp. Usurpation unraveling of the warp is carried out from each of the warp bobbin of two or more weights around which the warp which consists of flat thread is wound on the other hand, using a comb, it lengthens in request density, two or more of these warp is arranged with it, making it the flat side of warp not contact other than the wire of a comb, and weaving is carried out by changing the flat side of each warp horizontally and leading to a heddle.

[0032] Thus, in the case of the textiles by which weaving was carried out, a twist does not go into warp and weft yarn, the flat state of warp and weft yarn is held, and thread configurations, such as a thread width and thread thickness, hardly change, either. The sandwich-structure material shown by drawing 1 can be manufactured as follows, for example.

[0033] First, the textiles of carbon fiber flat thread as shown by drawing 2 are flooded with the resin liquid which comes to dilute a matrix resin with a solvent like a methanol, and it performs resin sinking in on textiles. Subsequently, textiles are taken out, dryness removal of the solvent is carried out, and the textile prepreg to which the resin of the specified quantity has adhered is prepared. While hardening a matrix resin and forming epidermis material by carrying out the laminating of the request number of sheets of the obtained textile prepreg, occurring the core material which processed the request configuration on it, setting the whole into an autoclave and carrying out heat-and-pressure processing by predetermined temperature and the predetermined pressure, after carrying the above-mentioned textile prepreg of request number of sheets on the core material further, the epidermis material and core material are pasted up.

[0034] the above-mentioned operative condition -- although it set like and the strengthening fiber materials in the fiber strengthening resin board which is epidermis material were the textiles of carbon fiber flat thread, the strengthening fiber material of this invention is not limited to this, on the other hand, lengthened the carbon fiber thread which has the modulus of elasticity in tension described above and destructive strain energy in parallel with \*\*, and arranged it -- on the other hand, you may be \*\* material and textiles When epidermis material is the fiber strengthening resin board which carried out the laminating of the strengthening fiber material of two or more sheets, it may be arranged so that each strengthening fiber in epidermis material may gather in the same direction, and the strengthening fiber in each epidermis material may be mutually arranged at 0 degree / 90 degrees, +45 degrees / -45 degrees, and as the whole epidermis material shows false isotropy, you may carry out a laminating.

[0035] In this case, the orientation of the strengthening fiber of the strengthening fiber materials 5b and 5b in the epidermis material 2 in drawing 1 is made to carry out in 0 degree / the direction of 90 degree to the direction of arrow p of drawing, and, as for the strengthening fiber materials 5a and 5a, it is desirable to arrange the thing made to carry out orientation in +45 degrees / the direction of -45 degree to the direction of arrow p to a mirror symmetry to a core material 1. Moreover, the laminating of the carbon fiber flat thread textiles shown by drawing 2 and the usual carbon fiber textiles may be carried out, and you may make it epidermis material. In this case, if the former epidermis material is arranged to an outermost layer of drum, if the front face of the whole epidermis material turns into a smooth side and accepts the need, it can paint there, or it can stick other films, and can raise design nature.

[0036]

[Effect of the Invention] clear at the above explanation -- as -- the sandwich-structure material of this invention -- lightweight -- both penetration-proof and barn through nature -- although -- it excels and is useful as flooring and the interior material of the aircraft For this, a modulus of elasticity in tension is  $20 \times 10^3$  kgf/cm<sup>2</sup> as a strengthening fiber material which constitutes epidermis material. It is above and destructive strain energy is 4.0 mm-kgf/mm<sup>3</sup>. It is the effect which having used the carbon fiber thread which it is above brings about. It is the number of the main section [ in / the textiles / when textiles are especially used as a strengthening fiber material ] 400-60,000 pieces/m<sup>2</sup> It is the effect which having carried out and having made the covering factor (Cf) 95% or more brings about.

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TECHNICAL FIELD

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[Industrial Application] this invention relates to sandwich-structure material suitable as structure material like the flooring of the aircraft, or interior material in more detail about sandwich-structure material.

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PRIOR ART

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[Description of the Prior Art] In the field of an airframe like a satellite or the aircraft, the energy-saving effect based on lightweight-izing those structural materials is remarkable. Since there is much number of times of a service especially in the case of a civil aviation machine and flight distance is also long, aiming at mpg saving is pursued by lightweight-izing the structural material.

[0003] Among the structural materials of the aircraft, flooring, interior material, etc. are used all over the aircraft, and, as for the operating area, become quite heavy [ an operating weight ] quite widely. As a structural material like the above-mentioned flooring or interior material, from the former, the honeycomb-structure object was made into the core material, and the sandwich-structure material which pasted up the glass fiber strengthening resin board on the both sides as epidermis material has mainly been used, for example.

[0004] When it is used especially as flooring in the case of this sandwich-structure material, to excel in properties, such as bending strength, flexural rigidity, penetration-proof, and barn through nature, is demanded. Especially, if it says from the point of the security of the aircraft, to excel in penetration-proof and barn through nature is needed. For example, the following accident may be caused when the sandwich-structure material inferior to penetration-proof is used for flooring.

[0005] That is, the cargo compartment which a cabin has in a pressurization state as a pre-load room, and is located in the lower part of a cabin in the civil aviation machine under flight [ altitude ] is since it is not in the pressurization state. If a hole etc. will open in epidermis material by sharp member like the heel of female high-heeled shoe when penetration-proof is flooring excellent [ seldom ], the epidermis material by the side of a cargo compartment will exfoliate from a core material by the pressure by the side of a cabin, and destruction of flooring will progress. And it is because it will happen that the air by the side of a cabin flows into a cargo-compartment side with rapid vigor, the digit material supporting the floor is also destroyed, and the function of the whole aircraft stops if destruction of flooring progresses.

[0006] Moreover, barn through nature is a property which shows the property in which flooring and interior material intercept fixed time and flame, and suppress the expansion to the fire which broke out in the interior or the exterior of the aircraft, and it is usually judged by the size of a covering factor. the fiber strengthening resin board whose covering factor is epidermis material here -- setting -- area S1 the time of setting up a field -- the area S1 Area S2 which portions other than the strengthening fiber material which exists in the field concerned occupy from -- following -- the thing of the value computed based on formula:  $Cf(\%) = [(S1 - S2) / S1] \times 100$  is said

[0007] For example, it is a field S1 about the area of the opening section formed in the mixture section of warp and weft yarn when strengthening fiber materials are the textiles which carried out weaving of warp and the weft yarn, i.e., the main section. Area S2 which the value totaled inside described above It becomes. If this Cf value becomes large, since the above-mentioned opening section in a strengthening fiber material will decrease, resistance of as opposed to the blow by of flame in the epidermis material becomes large, and barn through nature's improves. And since the above-mentioned opening section has increased and the blow by of the flame from there becomes easy when Cf value is small epidermis material, barn through nature becomes low.

[0008] In the case of the conventional sandwich-structure material which makes a glass fiber strengthening resin board epidermis material, the melting point of a glass fiber is low, for example, since a glass fiber will be fused for a short time if epidermis material \*\*\*\*, barn through nature is inferior. The specific gravity of a glass fiber is as large as about 2.56, and moreover, since the elastic modulus is small, in order to fulfill the predetermined rigidity at the time of real use of sandwich-structure material, it is necessary to thicken thickness of epidermis material. However, since it is necessary for the amount of the glass fiber used to also increase when thickening thickness of epidermis material, the whole epidermis material will become heavy as a result.

[0009] By the way, in order to attain lightweight-ization of the sandwich-structure material used as flooring, interior material, etc. recently, using carbon fiber textiles is performed as a strengthening fiber material of the fiber strengthening resin board which is epidermis material. In this case, in order to raise the barn through nature of epidermis material (i.e., while enlarging Cf value of carbon fiber textiles, in order to raise the intensity of a fiber strengthening resin board), as carbon fiber textiles, what carried out weaving of the narrow carbon fiber thread with high density is usually used.

[0010] In the case of this epidermis material, the specific gravity is about 1.75 and a carbon fiber's is lightweight compared with said glass fiber. And since the property demanded as epidermis material can fully be fulfilled, even if mechanical properties, such as bending strength and flexural rigidity, make thickness of epidermis material thin, considering only a relation with this mechanical property, they are not inconvenient. However, thickness of epidermis material cannot be made

not much thin, considering the point of reservation of penetration-proof. Therefore, as a result, since thickness of epidermis material must be thickened, remarkable lightweight-ization is not attained.

[0011] Moreover, first, if a flame is applied to this epidermis material, although it is small, flame will blow from the part where a carbon fiber does not exist but only a matrix resin exists, i.e., the main section. And with the passage of time, the oxidative consumption of a carbon fiber located near the main section progresses, the small blow-by hole becomes large at the beginning, and flame starts from there highly.

[0012] And when strengthening fiber materials are the high-density textiles of the above-mentioned narrow carbon fiber thread, the textiles have much number of the main section per unit area, namely, since the interval between the adjoining main sections is narrow, it is easy for the flame blown from each main section to gather to the inside of a short time, to turn into big flame, and to generate the situation of starting highly. Moreover, mutual fiber orientation should become 0 degree / 90 degrees, +45 degrees / -45 degrees about the epidermis material which becomes in piles so that mutual fiber orientation may turn into the same direction in the textiles of two or more sheets, and the textiles of two or more sheets. When each textiles are originally piled up since there was much number of the main section in each textiles even if it is the case where the mechanical property which becomes in piles is the epidermis material of false isotropy, like the case where the area which overlaps the frequency which the main section overlaps also became large, and is described above, the small flame blown from the main section gathers for a short time, and tends to turn into big flame.

[0013] Furthermore, since the front face of textiles has become that the carbon fiber textiles compounded with a matrix resin carry out weaving of the narrow carbon fiber thread with high density by incurvation of weaving yarn in the concavo-convex field, there is a problem that the front face turns into a concavo-convex field, and since weaving yarn itself is expensive, the obtained epidermis material also has the problem of becoming expensive also in itself [ sandwich-structure material ].

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EFFECT OF THE INVENTION

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[Effect of the Invention] clear at the above explanation -- as -- the sandwich-structure material of this invention -- lightweight -- both penetration-proof and barn through nature -- although -- it excels and is useful as flooring and the interior material of the aircraft For this, a modulus of elasticity in tension is  $20 \times 10^3$  kgf/cm<sup>2</sup> as a strengthening fiber material which constitutes epidermis material. It is above and destructive strain energy is 4.0 mm-kgf/mm<sup>3</sup>. It is the effect which having used the carbon fiber thread which it is above brings about. It is the number of the main section [ in / the textiles / when textiles are especially used as a strengthening fiber material ] 400-60,000 pieces/m<sup>2</sup> It is the effect which having carried out and having made the covering factor (Cf) 95% or more brings about.

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**TECHNICAL PROBLEM**

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[Problem(s) to be Solved by the Invention] this invention solves the above-mentioned problem in the conventional sandwich-structure material, is lightweight as a whole, is excellent in penetration-proof and barn through nature, and aims at offer of the sandwich-structure material which a front face can manufacture cheaply flat and smooth.

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MEANS

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[Means for Solving the Problem] It sets to the sandwich-structure material of structure which pasted up the fiber strengthening resin board which becomes both sides of a core material from a strengthening fiber material and a matrix resin in this invention in order to attain the above-mentioned purpose, and, for the aforementioned strengthening fiber material, a modulus of elasticity in tension is  $20 \times 10^3$  kgf/cm<sup>2</sup>. It is above and destructive strain energy is 4.0 mm-kgf/mm<sup>3</sup>. The sandwich-structure material characterized by the bird clapper from the carbon fiber thread which it is above is offered.

[0016]

[Example] Below, the example of the sandwich-structure material of this invention is \*(ed) on a drawing, and it explains in detail. drawing 1 shows the sandwich-structure material A -- it is a notch perspective diagram in part In drawing, epidermis material has pasted both sides of the core material 1 which is a honeycomb-structure object, and each epidermis material has become the fiber strengthening resin board which carried out the laminating of the strengthening fiber materials 5a and 5b of two or more sheets ( drawing 1 two sheets).

[0017] considering [ of securing a mechanical strength while a core material 1 attains lightweight-ization of the whole sandwich-structure material ] -- the density -- 0.017 - 0.17 g/cm<sup>3</sup> it is -- things are desirable Density is 0.017 g/cm<sup>3</sup>. The sandwich-structure object with which the mechanical strength became low and the small thing was obtained becomes easy to cause buckling, and cannot fully demonstrate the function as a core material of structure material, and is 0.17 g/cm<sup>3</sup>. It is because the whole weight will become heavy and will come to be contrary to the intention of lightweight-izing, if a large thing is used.

[0018] As a core material 1, you may use a plastics foam out of the illustrated honeycomb-structure object. When using sandwich-structure material as interior material of the aircraft, since a core material 1 is it incombustibility that a core material 1 is the honeycomb-structure object of aluminum, it is suitable. Moreover, since each of honeycomb-structure objects which sank phenol resin into the honeycomb of aramid fiber paper, phenol forms in which phenol resin was made to foam is self-reduction-of-inflammation nature and fire retardancy, they is suitable as a core material 1.

[0019] Below, the epidermis material 2 is explained. The epidermis material 2 is the fiber strengthening resin board which compounded the strengthening fiber material and matrix resin by a strengthening fiber material consisting of carbon fiber thread. As a matrix resin which constitutes this fiber strengthening resin board, an epoxy resin, phenol resin, an unsaturated polyester resin, thermosetting resin like vinyl ester resin, polyamide resin, polyester resin, a polyethylene resin, polypropylene resin and a polyphenylene sulfide resin, polyimide resin, a polyether ether resin, ABS plastics, thermoplastics like an acetal resin, etc. can be raised, for example.

[0020] these matrices resin -- for example, phosphoric ester, a halogenated hydrocarbon, an antimony oxide and boric-acid zinc, a phosphorus-containing polyol, a bromine-containing polyol, and a phthalic anhydride tetrachloride -- a well-known flame retarder like phthalic anhydride may be blended 4 bromination, and fire retardancy may be given In this case, since gas constituents detrimental to a human body may be generated from these flame retarders at the time of combustion of a matrix resin, you should restrict the loadings of a flame retarder to the proper quantity.

[0021] Since the work to which phenol resin equips with the fire retardancy which was excellent even if it did not blend a flame retarder, it remains as carbide if it is after combustion, since there is little generating capacity at the time of combustion and the coking value is high, and it intercepts flame among the above-mentioned matrix resins is demonstrated, it is suitable. As for the compound rate of a matrix resin, in this fiber strengthening resin board, it is desirable that it is 35 - 65% of the weight. It is because the improvement in on the strength accompanying composite-izing with fiber and a resin becomes inadequate even if the rate of a strengthening fiber material increases more than 65 % of the weight, and the rate of a strengthening fiber material becomes less than 35 % of the weight when [ than 65 % of the weight ] more, and it is which case when there are few these rates than 35 % of the weight.

[0022] Next, as carbon fiber thread used as a strengthening fiber material, although you may be any, such as carbon fiber thread of a PAN system, and carbon fiber thread of a pitch system, the high toughness carbon fiber thread which has the following property is used. Namely, JIS The modulus of elasticity in tension (E:kgf/mm<sup>2</sup>) measured based on R7601 is  $20 \times 10^3$  kgf/mm<sup>2</sup>. It is above and destructive strain energy (W:mm-kgf/mm<sup>3</sup>) is 4.0 mm-kgf/mm<sup>3</sup>. It is the above carbon fiber thread.

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[0027] However, if there is too little number of the main section 4, the flexibility to a shear strain becomes small, and in case the textiles fabricate the prepreg which comes to carry out resin sinking in along with a curved surface on these textiles at the time of manufacture of epidermis material, a wrinkle etc. will come to generate them on the surface of a Plastic solid. The number of the main section 4 in textiles since it is such is 400 pieces/m<sup>2</sup>. Carrying out above is desirable.

[0028] Moreover, since the adjoining interval between the main sections becomes narrow when there is too much number of the main section 4, the flame which blew the main section gathers for a short time, and tends to grow up to be big flame, and the barn through nature of epidermis material falls. Therefore, the number of the main section 4 is 60,000 pieces/m<sup>2</sup>. It is desirable to make it below. Furthermore, in the textiles to be used, with textiles with small Cf value, since the main aspect product per piece is large, the resin which is burying the main section burns, it blows from the main section, and time to grow up to be big flame becomes short. Therefore, as for Cf value in the textiles used by this invention, it is desirable that it is 95% or more.

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[0032] Thus, in the case of the textiles by which weaving was carried out, a twist does not go into warp and weft yarn, the flat state of warp and weft yarn is held, and thread configurations, such as a thread width and thread thickness, hardly change, either. The sandwich-structure material shown by drawing 1 can be manufactured as follows, for example.

[0033] First, the textiles of carbon fiber flat thread as shown by drawing 2 are flooded with the resin liquid which comes to dilute a matrix resin with a solvent like a methanol, and it performs resin sinking in on textiles. Subsequently, textiles are taken out, dryness removal of the solvent is carried out, and the textile prepreg to which the resin of the specified quantity has adhered is prepared. While hardening a matrix resin and forming epidermis material by carrying out the laminating of the request number of sheets of the obtained textile prepreg, occurring the core material which processed the request configuration on it, setting the whole into an autoclave and carrying out heat-and-pressure processing by predetermined temperature and the predetermined pressure, after carrying the above-mentioned textile prepreg of request number of sheets on the core material further, the epidermis material and core material are pasted up.

[0034] the above-mentioned operative condition -- although it set like and the strengthening fiber materials in the fiber strengthening resin board which is epidermis material were the textiles of carbon fiber flat thread, the strengthening fiber material of this invention is not limited to this, on the other hand, lengthened the carbon fiber thread which has the modulus of elasticity in tension described above and destructive strain energy in parallel with \*\*, and arranged it -- on the other hand, you may be \*\* material and textiles When epidermis material is the fiber strengthening resin board which carried out the laminating of the strengthening fiber material of two or more sheets, it may be arranged so that each strengthening fiber in epidermis material may gather in the same direction, and the strengthening fiber in each epidermis material may be mutually arranged at 0 degree / 90 degrees, +45 degrees / -45 degrees, and as the whole epidermis material shows false isotropy, you may carry out a laminating.

[0035] In this case, the orientation of the strengthening fiber of the strengthening fiber materials 5b and 5b in the epidermis material 2 in drawing 1 is made to carry out in 0 degree / the direction of 90 degree to the direction of arrow p of drawing, and, as for the strengthening fiber materials 5a and 5a, it is desirable to arrange the thing made to carry out orientation in +45 degrees / the direction of -45 degree to the direction of arrow p to a mirror symmetry to a core material 1. Moreover, the laminating of the carbon fiber flat thread textiles shown by drawing 2 and the usual carbon fiber textiles may be carried out, and you may make it epidermis material. In this case, if the former epidermis material is arranged to an outermost layer of drum, if the front face of the whole epidermis material turns into a smooth side and accepts the need, it can paint there, or it can stick other films, and can raise design nature.

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[Translation done.]